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<b>(54) Title:</b> A SUBSTANCE FOR LOWERING HIGH CHOLESTEROL LEVEL IN SERUM AND A METHOD FOR PREPARING THE SAME  <b>(57) Abstract</b>  The invention relates to a substance which lowers cholesterol levels in serum and which is a $\beta$ -sitostanol fatty acid ester or fatty acid ester mixture, and to a method for preparing the same. The substance can be used as such or added to food.		

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A substance for lowering high cholesterol level in serum and a method for preparing the same

5 A high cholesterol level in serum can be lowered effectively by altering the intestinal metabolism of lipids. In this case the aim may be to hamper the absorption of triglycerides, cholesterol or bile acids. It has been observed in a number of investigations that certain plant sterols, such as  $\beta$ -sitosterol (24-ethyl-5-cholestene-3 $\beta$ -ol) and its  
10 hardened form,  $\beta$ -sitostanol (24-ethyl-5 $\alpha$ -cholestane-3 $\beta$ -ol), lower serum cholesterol levels by reducing the absorption of dietary cholesterol from the intestines (1-25). The use of plant sterols can be considered safe, since plant sterols are natural components of vegetable fats and oils.  
15 Plant sterols themselves are not absorbed from the intestines, or they are absorbed in very low concentrations. A decreased incidence of coronary disease is clearly associated with a decrease in serum cholesterol, in particular LDL cholesterol. A high serum cholesterol value is the most  
20 significant single indicator of the risk of coronary disease.

The degree of cholesterol absorption depends on a hereditary property, apoprotein E-phenotype. Apoprotein E is a  
25 protein which belongs to serum lipoproteins and takes part in the transport of cholesterol in the system (26). Of alleles associated with the synthesis of apoprotein E, i.e. the lipoprotein which affects absorption, there are known  
30 three types, e2, e3, and e4, which combine in pairs at random. Alleles are capable of forming in total six different combinations. The higher the sum of the subindices, the better absorbable the cholesterol and the higher the level of cholesterol, in particular bad LDL cholesterol, in the  
35 serum (27). e4 allele is overrepresented among the hereditary factors of Finns, so that its proportion is almost double as compared with many European populations (28).

Finns are indeed exceptionally sensitive to dietary flaws and to fatty and high-cholesterol food (29).

Serum cholesterol levels can be lowered by dietary means, by paying attention to the quantity and type of the fat ingested and to the amount of cholesterol intake. In practice, however, these means do not always lead to a satisfactory end result. Other methods, suitable for the entire population, for reaching serum cholesterol levels lower than the present ones must be searched for. Increasing the fiber content of food is a method of limited effect. The cholesterol-lowering effect of soluble fiber in food is based on the binding and removal of bile acids. Since the absorption of cholesterol is of fundamental significance in the regulation of the cholesterol level in serum, it is logical to aim at developing methods by which the absorption of cholesterol can be prevented or reduced.

Pollak demonstrated that ingested plant sterol lowered the level of serum cholesterol in man (1). The same had previously been observed in experimental animals (2, 3). It has been observed in a number of investigations that large doses of plant sterols lower the levels of serum cholesterol, at best by 10-20 % (4, 5). In these experiments, large amounts, up to 24 g/day, of  $\beta$ -sitosterol in crystalline form were used (6). In certain experiments the serum cholesterol level was lowered significantly even with lower doses (7), although a small amount of soluble sitosterol administered in the form of fatty acid esters did not seem to lower serum cholesterol very effectively (8). Sitosterol preparations have in general been well tolerated in long-term use (9).

Natural plant sterols resemble cholesterol in their structure. The differences between a cholesterol molecule and a plant sterol molecule are primarily found in the structure of the side chain of the basic frame. An ordinary diet

contains plant sterols 100 - 300 mg/day. Most of the plant sterol in the diet is  $\beta$ -sitosterol, and approx. one-third is campesterol. Small amounts of saturated  $5\alpha$ -sitostanols are also present in food. Usually the campesterol concentrations in serum in particular reflect the degree of absorption of cholesterol (10, 11, 12). Variation in the amounts of plant sterols in the diet affects the serum cholesterol level, but this is an area which has not been studied much. Plant sterols are poorly absorbed from the intestines. Plant sterols which are scantily absorbed into the system (less than 10 % of the sterols) (30, 31, 32) are excreted in the bile and through that in the stools. At present it is easy to measure sterol levels from food, serum or stool samples by gas chromatographic methods. The levels in serum are in part dependent on the plant sterol amounts derived from the diet and in part on the efficiency of the absorption of sterols. In general the plant sterol levels in serum remain below 1/300 of the serum cholesterol level, since the absorbed plant sterol fraction is excreted from the system in the bile.

Even large ingested doses of plant sterols do not show in serum plant sterol levels. The values remain at the normal level, since in man the plant sterol absorption capacity is rapidly saturated. The serum plant sterol level rises to a detrimental level in a few rare diseases such as cerebrotendinotic xanthomatosis and sitosterolemia (33, 34, 35), in connection with which coronary disease is common. The incidence of these diseases is at maximum a few cases in a population of one million. Not a single case of these diseases has been observed in Finland. High plant sterol values are at times observed in patients suffering from certain hepatic diseases (36).

Studies of the metabolism of cholesterol have shown that sitosterol inhibits the absorption of both endogenic and dietary cholesterol from the intestines (13, 14). As a

result of this, the excretion of neutral steroids in the stools increases, which leads to a shortage of cholesterol in the liver and through that to a decreased serum cholesterol level. On the other hand, sitosterol does not affect the absorption of bile acids (13).

On the basis of experiments on animals, it seems that the action of sitosterol is based on its ability to displace dietary cholesterol in bile acid micelli (15, 16, 17). Similar results have also been obtained in man (37). Various plant sterols have been demonstrated to affect in different ways the absorption of cholesterol (19, 38). Previous studies carried out on experimental animals give the impression that sitostanol is the most effective inhibitor of cholesterol absorption (38) and is itself almost non-absorbable. Furthermore, an uncontrolled study on six subjects showed that free sitostanol (1.5 g/day) lowered the serum cholesterol (mainly LDL cholesterol) in four weeks by as much as 15 %. During a pause of two weeks, the cholesterol values returned to the previous levels (20). Most plant sterol preparations contain a number of different plant sterols. The effect of a plant sterol mixture on the absorption of cholesterol varies, as does their own absorption (21, 22, 23).

The studies carried out so far have mainly concentrated on investigating how the form (crystalline, suspension, granular) in which plant sterols are dosed affects their efficacy in lowering serum cholesterol levels. Crystalline plant sterols do not to a significant degree dissolve in the micelli phase in the alimentary canal, and are therefore not capable of efficiently inhibiting cholesterol absorption. Oils and fats are only to a limited degree capable of dissolving free sterols. Only in a dissolved form do sterols inhibit the absorption of cholesterol. According to Heinemann and coworkers (24), sitostanol inhibited in an infusion experiment the absorption of cholesterol 82 %,

whereas sitosterol respectively inhibited the absorption  
50 %.

5 In certain studies, fatty acid esters of sitosterol, such  
as sitosterol acetate or oleate or stigmasterol oleate dis-  
solved in fat, have been used. In experiments on rats an  
"oil" of this type, having a sterol concentration up to  
8 %, reduced the absorption of cholesterol by 20-40 % (22).  
10 During a high-cholesterol diet (500 mg/day), sitosterol  
oleate (2 g/day) dissolved in fat decreased the absorption  
of cholesterol in the test subjects on average by 33 %  
(25). In the same study, sitosterol mixed with food and in  
a lower dose (1 g/day) decreased the absorption of chol-  
esterol by 42 %.

15 A German patent (Deutsches Patentamt, Offenlegungsschrift  
2035069/January 28, 1971) relates to the adding of plant  
sterol fatty acid esters to cooking oil with the objective  
of lowering the serum cholesterol levels in man. The said  
20 patent proposes for use in the esterification of free ste-  
rols a method which in no case fulfills the requirements  
for the preparation of a food-grade product. According to  
the patent, the esterification is carried out between a  
free sterol and a fatty acid anhydride, with perchloric  
25 acid acting as a catalyst. The catalyst and reagent used  
cannot be accepted in a food process. In addition, the said  
patent relates to the fatty acid esters of only native  
plant sterols.

30 Many reagents which cannot be accepted as a food or for the  
production of a product intended as an additive for foods  
have been used in the preparation of sterol fatty acid  
esters. The use of, for example, chlorine (39), bromine  
(40), thionyl chloride (41) or anhydride derivatives of  
35 fatty acids is common. Of the methods previously patented,  
only the method of Baltes (Deutsches Patentamt, Offen-  
legungsschrift 2248921/April 11, 1974) for the esteri-

fication of sterols present in oils and fats by a chemical interesterification technique fulfills the criteria of food processes. In the said patent, free sterol and an excess of fatty acid esters are added to a mixture of oil or fat, whereafter the entire fatty mixture is interesterified by a commonly known interesterification technique.

The invention according to the present invention relates to the use of a sterol of an entirely different type for lowering the cholesterol level in serum. What is involved is fatty acid esters of  $5\alpha$ -saturated sterols, especially sitostanol fatty acid esters (sitostanol = 24-ethyl- $5\alpha$ -cholestane- $3\beta$ -ol), which have been observed to lower cholesterol levels in serum with particular efficacy. The said esters can be prepared or used as such, or they can be added to foods, especially to the fatty part of a food. The sitostanol fatty acid ester mixture is prepared by hardening a commercial  $\beta$ -sitosterol mixture (sitosterol = 24-ethyl- $5\beta$ -cholestene- $3\beta$ -ol).  $\beta$ -sitostanol can be prepared by a prior-known cholesterol hardening technique by hardening  $\beta$ -sitosterol by means of a Pd/C catalyst in an organic solvent (43). This mixture has the approval of the FDA (Cytellin, Eli Lilly). A hardening degree of over 99 % is achieved in the reaction. The catalyst used in the hardening is removed by means of a membrane filter, and the obtained sitostanol is crystallized, washed and dried. In accordance with the invention, the  $\beta$ -sitostanol mixture, which contains campestanol approx. 6 %, is esterified with different fatty acid ester mixtures by a commonly known chemical interesterification technique (44, 45, 46). A methyl ester mixture of the fatty acids of any vegetable oil can be used in the reaction. One example is a mixture of rapeseed oil and methyl ester, but any fatty acids which contain approx. 2-22 carbon atoms are usable. The method according to the invention for the preparation of stanol fatty acid esters deviates advantageously from the previously patented methods in that no substances other than free stanol, a fatty acid ester or



a fatty acid ester mixture, and a catalyst are used in the esterification reaction. The catalyst used may be any known interesterification catalyst, such as Na-ethylate.

5 It is also to be noted that in the method used in our application, contrary to the method of Baltes, referred to above, the fat itself is not interesterified. In this case the fatty part of a fat preparation or some other food will retain its natural properties. It should be noted further  
10 that the interesterified mixture can be added directly to fat-containing foods or be used as such. Since the stanol part of the mixture is non-absorbable, the energy content of the stanol fatty acid ester mixture is only 20-40 % of the energy content of a conventional oil or fat, depending  
15 on the fatty acid composition. Thus the mixtures can be used advantageously also as substances decreasing the energy content of a food.

The action of  $\beta$ -sitostanol fatty acid esters on cholesterol  
20 absorption and on serum cholesterol levels has not been studied previously. The study on which this application is based investigated how plant sterol concentrations in serum were affected by sitostanol (composition:  $\beta$ -sitostanol 94 % and campestanol 6 %), a hardened form of sitosterol, dissolved in rapeseed oil, both a) free and b) in the form of  
25 a fatty acid ester. The test arrangement of the study is shown in Diagram 1 in Appendix 1. The first step for all groups was a rapeseed oil intervention (50 g/d), for the control group a rapeseed oil intervention for the duration  
30 of the test, and for the other groups a compound according to the test arrangement scheme, added to rapeseed oil.

Table 1 in Appendix 2 shows that an increase in the  $\beta$ -sitostanol concentration of food lowered the concentrations  
35 of both  $\beta$ -sitosterol and campesterol in serum, but did not produce a clear change in the serum  $\beta$ -sitostanol concentrations. The results also show that an intake of  $\beta$ -sitostanol

in a soluble form - i.e. in the form of fatty acid esters - reduced the absorption of plant sterols more effectively than did free  $\beta$ -sitostanol taken in the same dosage. With respect to fatty acid esters of  $\beta$ -sitostanols there is additionally observed a clear dose response. It is evident that  $\beta$ -sitostanol also inhibits the absorption of  $\beta$ -sitosterol and campesterol, which can be seen as a decrease in their concentrations.

Respectively, the changes caused by stanol additions in the total and LDL serum cholesterol concentrations and in cholesterol absorption were also measured. The control group consumed ordinary rapeseed oil without stanol additions. Table 2 in Appendix 3 shows that cholesterol absorption was effectively reduced by a  $\beta$ -sitostanol fatty acid ester mixture (27.4 %) even if the stanol intake was relatively low, 895 mg/day. The cholesterol absorption of the control group did not change. The action of free  $\beta$ -sitostanol and a  $\beta$ -sitostanol fatty acid ester mixture on the cholesterol concentration in serum, as compared with the control group, is seen in Table 3 in Appendix 4. A  $\beta$ -sitostanol fatty acid ester mixture decreased both total cholesterol and LDL cholesterol more effectively than did free and  $\beta$ -sitostanol. A  $\beta$ -sitostanol fatty acid ester mixture dissolved in rapeseed oil (3.2 g of  $\beta$ -sitostanol/day) decreased total cholesterol by 9.5 % more and LDL cholesterol by 11.6 % more than did rapeseed oil alone. Respectively, the HDL/LDL cholesterol ratio rose significantly, from 0.32 to 0.52.

The studies carried out show clearly that by the addition of  $\beta$ -sitostanol fatty acid esters to, for example, food fats, significant advantages can be achieved both in the national nutrition and in the treatment of hypercholesterolemia, since 1) the mixture lowers cholesterol values in serum, 2) the mixture does not increase serum plant sterol concentrations, 3) the mixture can be used daily as a fat substitute in cooking normal food, even in large

doses (0.2 - 20 g/d), whereby the intake of energy from fat decreases.

5 Lipid changes caused by  $\beta$ -stanol fatty acid esters, observed in the study, are to be considered highly significant from the viewpoint of health. The significance of the results is emphasized by the possibility of using the compound alongside food preparations as part of ordinary cooking and an ordinary diet. Research results show that during  
10 an intervention diet the stanol level in serum does not rise, and that the levels of other plant sterols in the serum decrease. Thus the said  $\beta$ -stanol ester mixture is safe also for those few individuals who readily absorb all sterols or who have disturbances in sterol excretion. Fur-  
15 thermore, daily fat substitution decreases an individual's energy supply, since the effective stanol compound is not absorbed, i.e. it acts as a non-energy producing part of fat. There is no evidence of the said  $\beta$ -stanol ester mixture hampering the absorption of lipid-soluble vitamins or  
20 the vitamin levels in serum.

The uses of a sitostanol fatty acid ester mixture as a part of various fats and oils in fat-containing products are wide, since the physical properties of the mixture can be  
25 modified easily by altering the fatty acid composition of the mixture. In addition to this, the fatty acid composition of the  $\beta$ -stanol fatty acid ester mixture can be selected so as to contain large amounts of monoenes and poly-  
enes, whereby its efficacy in lowering the cholesterol  
30 levels in serum are enhanced.

Since the  $\beta$ -sitostanol fatty acid ester mixture is prepared using raw materials belonging to normal food and production processes generally used in the food industry, there are no  
35 obstacles to the production and use of the compound.

Example 1

A  $\beta$ -sitostanol ester mixture was prepared on a pilot scale. 6 kg of  $\beta$ -sitostanol which had been dried overnight at 60 °C was esterified with 8.6 kg of a rapeseed oil methyl ester mixture. The esterification was carried out as follows:

A mixture of  $\beta$ -sitostanol and rapeseed oil fatty acid methyl ester was heated in a reaction vessel at 90-120 °C and under a vacuum of 5-15 mmHg. The drying was continued for an hour, 12 g of Na ethylate was added, and the reaction was continued for approx. 2 hours. The catalyst was destroyed by adding water to the mixture. After phase separation, the oil phase was dried under a vacuum.

A conversion of 98 % was achieved in the reaction. The obtained ester mixture can be used as such as an additive in fats.

Instead of a mixture of rapeseed oil fatty acid esters it is possible to use in the reaction a methyl ester or a methyl ester mixture of the fatty acids of any vegetable oil, especially of fatty acids which contain approximately 2-22 carbon atoms.

Example 2

Before the steam blowing of rapeseed oil,  $\beta$ -sitostanol ester mixture prepared in Example 1 was added, at 3, 6, and 13 % by weight, to the rapeseed oil. Mayonnaises containing the said fat mixtures at 65 % were prepared.

Mayonnaise:

	%
fat mixture	65.0
thickening agent	2.0
salt	1.0
sugar	3.0
vinegar (10 wt.%)	3.0

11

mustard	2.0
water	24.0
total	100.0

5 The mayonnaise was prepared by homogenization by a known manner using a Koruma homogenizer.

10 There were no problems in the preparation of the mayonnaises, and their properties tested by sense perception did not differ from those of conventional mayonnaises.

#### Example 3

15 Before the steam blowing of oil,  $\beta$ -sitostanol ester mixture prepared in Example 1 was added, at 3 and 6 % by weight, to the rapeseed oil.

20 The rapeseed oil to which the ester mixtures had been added remained clear at room temperature, and no permanent turbidity was observed in it when it was stored at refrigerator temperatures.

#### Example 4

25 Other oils, such as sunflower, soybean, olive and corn oil, can also be used as the oil in the products according to Examples 2 and 3.

#### Example 5

30  $\beta$ -sitostanol ester mixture prepared in Example 1 was added, at 10 and 20 % by weight, to the fatty part of a conventional soft margarine (composition: partly hardened soybean oil 35 %, coconut oil 5 %, rapeseed oil 60 %) before the steam blowing of the fat mixture.

35 The DP (dropping point) and NMR values of the mixtures were analyzed

1) the mixture as such

- 2) the mixture + ester mixture at 10 %
- 3) the mixture + ester mixture at 20 %

5		Mixture DP (°C)	NMR values (%)				
			10°C	20°C	30°C	35°C	40°C 45°C
	1)	31.9	24.2	11.6	2.7	0.7	0.0 0.0
	2)	30.4	21.4	10.0	1.8	0.2	0.0 0.0
	3)	29.6	25.4	9.2	2.0	0.6	0.0 0.0

- 10 A margarine which contained fat 80 % was prepared by a generally known method. The physical and sense perceivable properties of the margarine corresponded to those of conventional margarines.

## DIAGRAM 1

Test arrangement of the intervention study.

## 5 TEST GROUPS

(n=22)

\*-----\*-----\*-----\*control (n=8)

10

-----\*

 $\beta$ -sitostanol

(n=7)

-----\*

 $\beta$ -sitostanol

ester

(n=7)

15

\*-----\*-----\*-----\*

0 wk.

6 wks.

15 wks.

21 wks.

20

INITIAL

EXPERIMENTAL

CONTINUATION PERIOD

**TABLE 1**

Changes (%) caused during the experimental period in plant sterol levels in serum by  $\beta$ -sitostanol added to rapeseed oil, and during the continuation period with respect to  $\beta$ -sitostanol ester (3150 mg/d).

	Stanol added to rapeseed oil (mg/d)	Change (%) caused by the addition <sup>1</sup>		
		Campesterol	$\beta$ -sitosterol	$\beta$ -sitostanol
10	$\beta$ -sitostanol (895)	-18.4 <sup>x</sup>	-13.0 <sup>x</sup>	-0.6
	$\beta$ -sitostanol ester (895) <sup>2</sup>	-28.4 <sup>x</sup>	-23.4 <sup>x</sup>	-10.3
15	$\beta$ -sitostanol ester (3150) <sup>2</sup>	-51.7 <sup>x</sup>	-43.3 <sup>x</sup>	-10.3

1) = Change in the table has been corrected by the %-change in the control group which had received rapeseed oil

2) = amount in free stanol

x) = change is significant as compared with the change in the control group,  $p < 0.05$



TABLE 2

Effect of rapeseed oil and  $\beta$ -sitostanol ester dissolved in it on the absorption of cholesterol.

5	Group (mg/d)	Cholesterol absorption at the intervention period		Change (%)
		beginning	end	
10	Control	Rapeseed oil	Rapeseed oil	
		29.4	30.4	+3.4
15	$\beta$ -sitostanol ester	Rapeseed oil	Rapeseed oil + $\beta$ -sitostanol ester	
		29.2	21.2 <sup>xt</sup>	-27.4

x) = change is significant,  $p < 0.05$

20 t) = change is significant as compared with the change in the control group,  $p < 0.05$

1) = amount in free stanol

TABLE 3

Effect in serum of  $\beta$ -sitostanol added to rapeseed oil on cholesterol levels

5	Stanol added to rapeseed oil (mg/d)	Change (%) caused by the addition <sup>1</sup> total cholesterol    LDL cholesterol
10	$\beta$ -sitostanol (895)	-2.1            -6.4
	$\beta$ -sitostanol ester (3150)	-9.5 <sup>xt</sup> -11.6 <sup>t</sup>

15        1) = change has been corrected by the %-change in the control group which had received rapeseed oil

x) = change is significant,  $p < 0.05$

20        t) = change is significant as compared with the change in the control group,  $p < 0.05$

- 1) Pollak, O.J., Reduction of blood cholesterol in man. Circulation, 7, 702-706, (1953).
- 5      2) Peterson, D.W., Effect of soybean sterols in the diet on plasma and liver cholesterol in chicks, Pric. Soc. Exp. Biol. Med., 78, 143-147, (1951).
- 10     3) Pollak, O.J., Succesful prevention of experimental hypercholesterolemia and cholesterol atheroscleroses in the rabbit, Circulation, 7, 696-701, (1953).
- 15     4) Farquhar, J.W. and Sokolow, M., Response of serum lipids and lipoproteins of man to beta-sitosterol and safflower oil - A long term study, Circulation, 17, 890, (1956).
- 20     5) Grundy, S.M., Ahrens, E.H. Jr., and Davignon, J., The interaction of cholesterol absorption and cholesterol synthesis in man, J. Lipid Res., 10, 304, (1969).
- 25     6) Oster, P., Schlierf, G., Heuck, C.C., Greten, H., Gundert-Remy, U., Haase, W., Klose, G., Nothelfer, A., Raetzer, H., Schellenberg, B. und Schmidt-Gayk, H., Sitosterin bei familiären Hyperlipoproteinämie Typ II. Eine randomisierte gekreuzte Doppelblindstudie, Dtsch. Med. Wschr., 101, 1308-1311, (1976).
- 30     7) Grundy, S.M., Dietary and drug regulation of cholesterol metabolism in man, pp. 127-159 in "Lipid Pharmacology, Vol II", Eds: Paoletti, R and Glueck, C.J., Academic Press, New York, 1976.
- 35     8) Lees, A.M., Mok, H.Y.I., McCluskey, M.A., Grundy, S.M., Plant sterols as cholesterol lowering agents: clinical trials in patients with hypercholesterolemia and studies of sterol balance, Atherosclerosis, 28, 325-338. (1977).

- 9) Schwartzkopf, W. and Jantke, H.-J., Dosiswirksamkeit von Beta-sitosterin bei Hypercholesterinemien der Typen II A und II B, Munch. Med. Wschr., 120, 1575, (1969).
- 5 10) Tilvis, R.S., Miettinen, T.A., Serum plant sterols and their relation to cholesterol absorption, Am. J. Clin. Nutr., 43, 92-97, (1986).
- 10 11) Miettinen, T.A., Tilvis, R.S., Kesäniemi, Y.A., Serum plant sterols and cholesterol precursors reflect cholesterol absorption and synthesis in volunteers of a randomly selected male population, Am. J. Epidemiol., 131, (1), 20-31. (1990).
- 15 12) Färkkilä, M.A., Tilvis, R.S., Miettinen, T.A., Regulation of plasma plant sterols levels in patients with gut resections, Scand. J. Clin. Lab. Invest., 48, 715-722, (1988).
- 20 13) Grundy, S.M., Mok, H.Y.I., Effects of low dose phytosterols on cholesterol absorption in man, pp. 112-118 in "Lipoprotein metabolism". Ed. Greten, H., Berlin, Heidelberg, New York: Springer-Verlag, 1976
- 25 14) Kudchodkar, B.J., Horlick, L., Sodhi, H.S., Effects of plant sterols on cholesterol metabolism in man, Atherosclerosis, 23, 239, (1976).
- 30 15) Ikeda, I., Tanaka, K., Sugano, M., Vahouny, G.V., Gallo I.L., Inhibition of cholesterol absorption in rats by plant sterols, J. Lipid Res., 29, 1573-1582, (1988).
- 35 16) Ikeda, I., Tanaka, K., Sugano, M., Vahouny, G.V., Gallo, I.L., Discrimination between cholesterol and sitosterol for absorption in rats, J. Lipid Res., 29, 1583-1592, (1988).

- 17) Ikeda, I., Tanabe, Y. and Sugano, M., Effects of sitosterol and sitostanol on micellar solubility of cholesterol, J. Nutr. Sci. Vitaminol., 35, 361-369, (1989).
- 5 18) Ikeda, I., Sugano, M., Comparison of absorption and metabolism of beta-sitosterol and beta-sitostanol in rats, Atherosclerosis, 30, 227, (1978).
- 10 19) Sugano, M., Marioka, H. and Ikeda, I., A comparison of hypocholesterolemic activity of  $\beta$ -sitosterol and  $\beta$ -sitostanol in rats, J. Nutr., 107, 2011-2019, (1977).
- 15 20) Heinemann, T., Leiss, O., von Bergman, K., Effects of low-dose sitostanol on serum cholesterol in patients with hypercholesterolemia, Atherosclerosis, 61, 219-223, (1986).
- 20 21) Lees, R.S., Lees, A.M., Effects of sitosterol therapy on plasma lipids and lipoprotein concentrations, pp. 119-124 in "Lipoprotein metabolism". Ed: Greten, H., Berlin, Heidelberg, New York: Springer-Verlag, 1976.
- 25 22) Mattson, F.H., Volpenhein, R.A. and Erickson, B.A.: Effect of plant sterol esters on the absorption of dietary cholesterol, J. Nutr., 107, 1139-1146, (1977).
- 30 23) Heinemann, T., Pietruck, B., Kullak-Ublick, G., von Bergman, K., Comparison of sitosterol and sitostanol on inhibition of intestinal cholesterol absorption, Agents Actions (Suppl), 26, 117-122, (1988).
- 35 24) Heinemann, T., Kullak-Ublick, G.-K., Pietruck, B., von Bergmann, K., Mechanisms of action of plant sterols on inhibition of cholesterol absorption, Eur. J. Clin. Pharmacol., 40 Suppl. 1, S50-S63, (1991).

- 25) Mattson, F.H., Grundy, S.M., Crouse, J.R., Optimizing the effect of plant sterols on cholesterol absorption in man, *Am. J. Clin. Nutr.*, 35, 697-700, (1982).
- 5 26) Kesäniemi, Y.A., Ehnholm, C., Miettinen, T.A., Intestinal cholesterol absorption efficiency in man is related to apoprotein E phenotype, *J. Clin. Invest.*, 80, 578-581, (1987).
- 10 27) Kesäniemi, Y.A., Miettinen, T.A., Metabolic epidemiology of plasma cholesterol, *Ann. Clin. Res.*, 20, 26-31, (1988).
- 15 28) Ehnholm, C., et al., Apolipoprotein polymorphism in the Finnish population: gene frequencies and relation to lipoprotein concentrations, *J. Lipid. Res.* 27, 227-235, (1986).
- 20 29) Miettinen, T.A., Gylling, H., Vanhanen, H., Serum cholesterol response to dietary cholesterol and apoprotein E phenotype, *Lancet*, 2, 1261, (1988).
- 30 30) Gould, G., Absorbability of beta-sitosterol, *Trans. N.Y. Acad. Sci.*, 2, 129, (1955).
- 25 31) Gould, R.G., Jones, R.J., LeRoy, G.W., Wissler, R.W., Taylor, C.B., Absorbability of  $\beta$ -sitosterol in humans, *Metabolism*, 18, 652-662, (1969).
- 30 32) Salen, G., Ahrens, E.J., Grundy, S.M., Metabolism of  $\beta$ -sitosterol in man, *J. Clin. Invest.*, 49, 952-67, (1970).
- 35 33) Salen, G., Kwiterowich, P.O. Jr, Shefer, S., Tint, G.S., Horak, I., Shore, V., Dayal, B., Horak, E., Increased plasma cholestanol and  $5\alpha$ -saturated plant sterol derivatives in subjects with sitosterolemia and xanthomatosis, *J. Lipid Res.*, 26, 203-209, (1985).

34) Salen, G., Shore, V., Tint, G.S., Forte, T., Shefer, S., Horak, I., Horak, E., Dayal, B., Nguyen, L., Batta, A.K., Lindgren, F.T. and Kwiterowich, P.O., Jr., Increased sitosterol absorption, decreased removal and expanded body pools compensate for reduced cholesterol synthesis in sitosterolemia with xanthomatosis. J. Lipid Res., 30, 1319-1330, (1989).

35) Miettinen, T.A. Phytosterolemia, xanthomatosis and premature atherosclerosis disease: a case with high plant sterol absorption, impaired sterol elimination and low cholesterol synthesis, Eur. J. Clin. Invest., 10, 27-35, (1980).

36) Nikkilä, K., Miettinen, T.A., Serum cholesterol precursors, cholestanol and plant sterols in PBC, Scand. J. Gastroenterol., 23, 967-972, (1988).

37) Miettinen, T.A., Siurala, M., Bile salts, sterols, sterol esters, glycerides and fatty acids in micellar and oil phases of intestinal contents during fat digestion in man, Z. Klin. Chem. Biochem., 9, 47-52, (1971).

38) Hassan, A.S., Rampone, A.J., Intestinal absorption and lymphatic transport of cholesterol and  $\beta$ -sitostanol in the rat, J. Lipid Res., 20, 646-653, (1979).

39) Kuksis, A., Beveridge, J.M.R., J. Org. Chem, 25:1209, (1960).

40) Saroja, M., Kaimal, T.N.B., A convenient method of esterification of fatty acids. Preparation of alkyl esters, sterol esters, wax esters and triacylglycerols, Synthetic communications, 16, 1423-1430, (1986).

41) Prabhudesai, A.V., A simple method for the preparation of cholesteryl esters, Lipids, 12, 242-244, (1977).

42) Lentz, B.R., Barenholz, Y., Thompson, T.E., A simple method for the synthesis of cholesterol esters in high yield, Chemistry and Physics of Lipids, 15, 216-221, (1975).

5

43) Augustine, R.L. and Reardon Jr., E.J., The palladium catalyzed hydrogenation of cholesterol, Organic preparations and procedures 1(2), 107-109, (1969).

10

44) Sreenivasan, B., Interesterification of fats, J. Am. Oil Chemists' Soc., 55, 796-805, (1978).

15

45) Lo, Y.C. and Handel, A.P., Physical and chemical properties of randomly interesterified blends of soybean oil and tallow for use as margarine oils, J. Am. Oil Chemists' Soc., 60, 815-818, (1983)

20

46) Chobanov, D., Chobanova, R., Alterations in glyceride composition during interesterification of mixtures of sunflower oil with lard and tallow, J. Am. Oil Chemists' Soc., 54, 47-50 (1977).



Claims

1. A substance lowering cholesterol levels in serum, characterized in that it comprises a  $\beta$ -sitostanol fatty acid ester or a  $\beta$ -sitostanol fatty acid ester mixture.
- 5 2. A substance according to Claim 1, characterized in that the fatty acids of the mixture contain 2-22 carbon atoms.
- 10 3. A substance according to any of Claims 1-2, characterized in that it has been brought to a form soluble in fats by esterifying free  $\beta$ -sitostanol with a fatty acid ester or a fatty acid ester mixture.
- 15 4. A substance according to any of Claims 1-3, characterized in that the substance is added to fat preparations or other foods.
- 20 5. A substance according to any of Claims 1-3, characterized in that it is used as an essential fat component or a fat substitute.
- 25 6. A substance according to Claim 5, characterized in that it is used in cooking oils, margarines, butter, mayonnaise, salad dressings, shortenings, etc.
- 30 7. A substance according to any of Claims 1-3, characterized in that it can be consumed as such, as part of the diet.
- 35 8. A process for the preparation of the substance according to Claim 1, characterized in that free  $\beta$ -sitostanol is esterified with a fatty acid ester or a fatty acid ester mixture in the presence of an interesterification catalyst.
9. A process according to Claim 8, characterized in that the reaction is carried out at a temperature of approx. 90 - 120 °C and under a vacuum of approx. 5 - 15 mmHg.

# INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 91/00139

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: C 07 J 9/00, A 61 K 31/575																	
<b>II. FIELDS SEARCHED</b> <div style="text-align: center; margin-top: 5px;">Minimum Documentation Searched<sup>7</sup></div> <table style="width: 100%; border: none;"> <tr> <td style="width: 20%; border: none;">Classification System</td> <td style="border: none;">Classification Symbols</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">IPC5</td> <td style="border: 1px solid black; padding: 5px;">C 07 J; A 61 K</td> </tr> </table> <div style="text-align: center; margin-top: 5px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched<sup>8</sup></div> <p style="margin-top: 10px;">SE,DK,FI,NO classes as above</p>			Classification System	Classification Symbols	IPC5	C 07 J; A 61 K											
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<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category<sup>*</sup></th> <th style="width: 60%;">Citation of Document,<sup>11</sup> with indication, where appropriate, of the relevant passages<sup>12</sup></th> <th style="width: 30%;">Relevant to Claim No.<sup>13</sup></th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>Chemical Abstracts, volume 71, no. 1, 7 July 1969, (Columbus, Ohio, US), see, abstract 3585w, &amp; JP, A, 44004974 (Sitosterol fatty acid ester) 1969 --</td> <td style="text-align: center; vertical-align: top;">1-9</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>EP, A1, 0289636 (ASAHI DENKA KOGYO KABUSHIKI KAISHA ET AL.) 9 November 1988, see the whole document --</td> <td style="text-align: center; vertical-align: top;">1-9</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>DE, A, 2035069 (THE PROCTER &amp; GAMBLE COMPANY) 28 January 1971, see the whole document --</td> <td style="text-align: center; vertical-align: top;">1-9</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>EP, A2, 0195311 (YOSHIKAWA OIL &amp; FAT CO., LTD.) 24 September 1986, see pages 8-14, the claims --</td> <td style="text-align: center; vertical-align: top;">8-9</td> </tr> </tbody> </table>			Category <sup>*</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>	X	Chemical Abstracts, volume 71, no. 1, 7 July 1969, (Columbus, Ohio, US), see, abstract 3585w, & JP, A, 44004974 (Sitosterol fatty acid ester) 1969 --	1-9	X	EP, A1, 0289636 (ASAHI DENKA KOGYO KABUSHIKI KAISHA ET AL.) 9 November 1988, see the whole document --	1-9	X	DE, A, 2035069 (THE PROCTER & GAMBLE COMPANY) 28 January 1971, see the whole document --	1-9	X	EP, A2, 0195311 (YOSHIKAWA OIL & FAT CO., LTD.) 24 September 1986, see pages 8-14, the claims --	8-9
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<div style="display: flex; justify-content: space-between;"> <div style="width: 48%;"> <p><b>* Special categories of cited documents:<sup>10</sup></b></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 48%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> </div> </div>																	
<b>IV. CERTIFICATION</b> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Date of the Actual Completion of the International Search</td> <td style="width: 50%; border: none;">Date of Mailing of this International Search Report</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">3rd December 1991</td> <td style="border: 1px solid black; padding: 5px;">1991 -12- 0 9</td> </tr> <tr> <td style="border: none;">International Searching Authority</td> <td style="border: none;">Signature of Authorized Officer</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px; text-align: center;">SWEDISH PATENT OFFICE</td> <td style="border: 1px solid black; padding: 5px;">             Eva Johansson         </td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	3rd December 1991	1991 -12- 0 9	International Searching Authority	Signature of Authorized Officer	SWEDISH PATENT OFFICE	 Eva Johansson							
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 3004043 (MAX H. STERN) 10 October 1961, see the whole document --	1-9
A	DE, A, 2422317 (LABORATORIOS FERRER S.L.) 21 November 1974, see the whole document --	1-9
A	Chemical Abstracts, volume 115, no. 1, 8 July 1991, (Columbus, Ohio, US), T. Heinemann et al.: "Mechanisms of action of plant sterols on inhibition of cholesterol absorption: comparison of sitosterol and sitostanol ", see, abstract 552z, & Eur. J. Clin. Pharmacol. 1991, 40( 1), 59- 63 --	1-9
A	Chemical Abstracts, volume 112, no. 7, 12 February 1990, (Columbus, Ohio, US), I. Ikeda et al.: "Effects of sitosterol and sitostanol on micellar solubility of cholesterol ", see, abstract 52798s, & J. Nutr. Sci. Vitaminol. 1989, 35( 4), 361- 369 --	1-9
A	Chemical Abstracts, vol. 112, no. 7, 2 February 1990 (Columbus, Ohio, US), T. Heinemann et al: "Comparison of sitosterol and sitostanol on inhibition of intestinal cholesterol absorption", abstract 48561s, & Agents Actions Suppl., 26 (Cologne Atheroscler. Conf., No. 4: Cholesterol- -Homeostatis), 117-22 --	1-9
A	Chemical Abstracts, volume 95, no. 13, 28 September 1981, (Columbus, Ohio, US), I. Ikeda et al.: "Antihypercholesterolemic activity of .beta.-sitostanol in rabbits ", see, abstract 108766e, & J. Nutr. Sci. Vitaminol. 1981, 27( 3), 243- 251 --	1-9
A	Chemical Abstracts, volume 88, no. 3, 16 January 1978, (Columbus, Ohio, US), M. Sugano et al.: "A comparison of hypocholesterolemic activity of .beta.-sitosterol and .beta.-sitostanol in rats ", see, abstract 21071f, & J. Nutr. 1977, 107(11), 2011-2019 -- -----	1-9

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. PCT/FI 91/00139**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 31/10/91. The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A1- 0289636	88-11-09	JP-A- 62186936	87-08-15
DE-A- 2035069	71-01-28	BE-A- 753648	71-01-18
		FR-A-B- 2059523	71-06-04
		GB-A- 1284814	72-08-09
		NL-A- 7010578	71-01-19
EP-A2- 0195311	86-09-24	CH-A-B- 667284	88-09-30
		JP-A- 62166895	87-07-23
		JP-A- 61204197	86-09-10
		JP-A- 62048391	87-03-03
US-A- 3004043	61-10-10	NONE	
DE-A- 2422317	74-11-21	AT-B- 336203	77-04-25
		AU-D- 6874774	75-11-13
		BE-A- 814741	74-09-02
		CH-A- 589673	77-07-15
		FR-A-B- 2228493	74-12-06
		GB-A- 1473574	77-05-18
		JP-A- 50129543	75-10-13
		JP-B- 53035071	78-09-25
		NL-A- 7406089	74-11-12